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The evaluation of bio-energy produced from ethanol fermentation using corncob dust hydrolysate

Jirawan Apiraksakorn[a,b,*], Sompong Sukklang[a] and Mallika Boonmee[a,b]

[a]*Department of Biotechnology, Faculty of Technology, Khon Kaen University, Thailand*
[b]*Fermentation Research Center for Value- Added Agricultural Products, Faculty of Technology, Khon Kaen University, Thailand*

Abstract

Corncob dust is a byproduct from animal feed industry. Based on the major components, it has potential as an alternative carbon source for bio-ethanol production. To determine maximum glucose from corncob dust, incremental variables were tested: first, corncob to acid ratio (1:5 - 1:15 w/v), then, sulfuric acid concentrations (0.5%, 2%, 5% v/v), next, temperatures (80-120°C) and reaction time (0-5 h). The maximum glucose of 2.80 g/l with 0.24 g/l xylose were obtained from the optimum hydrolysis conditions at 1:10 corncob to acid ratio using 2% sulfuric acid under 110°C for 5 h. The activation energy for glucose and xylose production from corncob dust hydrolysis estimated using Arrhenius equation were 108.1 and 40.7 kJ/mole, respectively. Ethanol yield from fermentation of corncob dust hydrolysate by *Candida shehatae* was 1.39 mole-ethanol/mole-glucose, which was equivalent to 1,807 kJ/mole-substrate. Energy produced from ethanol was 16.8 times higher than that from energy consumed in the hydrolysis process. Therefore, bio-energy production from corncob dust hydrolysate was very efficient.

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Keywords: Corncob; Hydrolysis; Glucose; Xylose; Activation energy

1. Introduction

Corncob dust is a byproduct of the corn processing industry that has been used either in animal feed or is returned to the field. It contains approximately 43.08 % cellulose, 27.34 % hemicelluloses, 4.89 % protein, 2.15% fat and 3.96 % ash of dry matter [1]. The major structural components are: crystalline cellulose which is a source of glucose, and amorphous hemicelluloses compose of pentose such as xylose, arabinose and hexose such as glucose, galactose

* Corresponding author. Tel.: +66-4320-2403; fax: +66-4336-2121.
E-mail address: jirapi@kku.ac.th

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and mannose. The digestion of agricultural residues yields primarily glucose 55-65% and xylose 35-45% [2, 3], which can potential be used as a carbon source for ethanol production [4, 5, 6, 7] instead of other high-cost agricultural food crops.

Dilute acid hydrolysis has been known as an effective method of breaking down plant components to sugar constituents [8, 9] before the sugar is fermented into ethanol by the microorganism. However, the amount of sugars released from the plant material is dependent on the reaction time, temperature and acid concentration [10]. The aim of this research was to find the optimum conditions for glucose production from corncob dust hydrolysis and to evaluate the activation energy produced by the breakdown of the corncob components into glucose and xylose according to the Arrhenius equation.

2. Materials and Methods

2.1. Corncob dust hydrolysis

Three kilogram of the corncob dust was mixed with 0.5 % (v/v) H_2SO_4 at ratio of 1:5, 1:10 and 1:15 (kg/L). The hydrolysis was carried out in the 50-litres bioreactor with an agitation rate of 60 rpm at 110°C for 5 h. The hydrolysate was centrifuged at 4°C, 10,000g for 15 min to separate the solid portion residue. The supernatant was analyzed for glucose concentration. The highest was selected to test the effect of H_2SO_4 at various concentrations of 0.5, 2.0 and 5.0 % (v/v).

2.2. Determination of reaction rate and activation energy

The corncob dust was hydrolyzed at the optimum corncob dust to acid ratio with various H_2SO_4 concentrations of 0.5, 2.0 and 5.0 % (v/v). The temperature was separately controlled at 80, 90, 100, 110 and 120°C. The samples were collected every hour to analyze the glucose and xylose concentration. The reaction rates were calculated as a function of glucose or xylose concentration per time.

The activation energy (E_a) required for glucose or xylose production from the corncob hydrolysis process was determined using the Arrhenius equation:

$$k = Ae^{Ea/RT} \quad (1)$$

In this equation, *k* is the rate constant for the reaction, A is a proportionality constant that varies from one reaction to another, E_a is the activation energy for the reaction, R is the ideal gas constant of 8.314 J/ mol-K, and T is the temperature in Kelvin (K).

2.3 Ethanol fermentation

The culture medium was composed of yeast extract 3 g/l, malt extract 3 g/l, peptone 5 g/l and corncob dust hydrolysate. *C. shehatae* TISTR5843 was grown in medium at 30°C, 200 rpm for 24 h. Inoculums were re-transferred to fresh medium containing corncob dust hydrolysate and continued grown at 30°C, 200 rpm, 24 h to propagate biomass. The cells were centrifuged (10,000 g, 5 min), washed with 0.85 % (w/v) normal saline and centrifuged again to harvest. The 2 g of yeast cells were re-suspended in the fermentation medium containing corncob dust hydrolysate and fermented at 30°C for 120 h. Samples were taken every 24 h for further analysis.

2.4 Analytical methods

Glucose, xylose and reducing sugar were analysed by the peroxidase glucose oxidase assay [11], by *p*-Bromoaniline method [12] and by Dinitrosalicylic acid (DNS) method [13], respectively. Ethanol was determined by Gas Chromatography (Shimadzu GC-14B, Kyoto, Japan, Solid phase: polyethylene glycol (PEG-20M), carrier gas: nitrogen, 150 °C isothermal packed column, injection temperature 180 °C, flame ionization detector temperature 250 °C; GC Solution analysis Version 2.30) and 2-propanol was used as an internal standard [14].